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BOTANY *

By Herbert Maule Richards

What is the content and scope of the science of botany? Popular opinion will answer somewhat easily: Botany consists in the gathering of plants, and the dismembering of them, in connection with the use of a complicated terminology. That is the beginning and end of botany as it is understood by the majority; there is nothing more to be said. In consequence, the employment of the botanist seems so trivial, so very remote from important human interests that no second thought is given to it. The conception formed in ignorance is continued in ignorance. Even the zoölogist is at an advantage, for the public is finally forced to admit that it does not know what he is about, while it understands the botanist very well. He is quite hopeless, for, while flowers may be pretty things to pick, they should not be pulled to pieces, and if he does not happen to be interested in dissecting flowers he is not a botanist but simply a fraud.

Far from being remote, the study of plants comes very close to human interests. One has but to stop to think that plants are the great energy source for man himself and the animals upon which his well-being depends, to recognize that a careful study of their manner of life, the conditions which favor or hinder their growth is of the very first importance. Besides this, human curiosity demands that plants be investigated, if for no other reason than that they must be made to yield answers to the perpetual questions that man is asking regarding the world about him.

Under botany we have to consider all the questions as to the

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form, the functions, the classification and the distribution of those organisms that are called plants. Along what lines this study is prosecuted, how it is related to other fields of intellectual activity, and some specific instances of its problems and the manner in which they may be solved is what I shall attempt to tell you.

It would be out of place in a talk like this to devote too much time to a consideration of the historical side of the subject, and therefore only a few of the important movements can be pointed out. Any folk which had so far emerged from the stage of savagery as to stop to notice the world about it would perforce pay some attention to plants. A discrimination of the medicinal uses of plants is often noticeable even in primitive peoples, and with such observation goes also the discrimination of difference in form, the prototype of morphological research. I have seen a Malay coolie who could distinguish seven forms of tropical oaks where the botanist recognizes only four, an evidence that sharp observation is not confined to the highly developed races.

In our own civilization, we can trace back the history of botany to Aristotle, who affords us some record of the plant forms known at his time, though the influence which his philosophy wielded, even down to the middle of the last century, was of vastly greater importance than any contribution which he made to botany itself. Theophrastus gave a fuller account of plants, and later came the inquiring and ever curious Pliny. Dioscorides, however, in the first or second century of our era, was one of the first to investigate plants with any attempt at thoroughness even from the standpoint of the knowledge of the time. As is shown especially by Dioscorides' work, the study of plants was largely from their use as drugs, and they were described simply to facilitate their recognition. Any real knowledge of them was naturally meager, and false ideas that clung for a long time, some until comparatively recently, prevented any proper conception of form and function.

As would be expected the contributions become of less and less value as we approach the middle ages, the botanical writings of which time were full of the wildest fantasy and superstition. The efforts of this period need not arrest our attention.

In the sixteenth century in northern Europe, particularly Germany, there was a movement towards the real study of plants from the plants themselves as evidenced by the works of the herbalists, but no attempt at classification was made. Here there was an attempt at the enumeration and illustration of plants from living specimens, and confused and empirical as this work was, it was actuated by an honest endeavor to record, as accurately as possible, actual forms, and not fanciful abstractions which never did and never could have existed. All the descriptions were detached from one another and little or no attempt was made at classification, though by the repeated study of many similar forms the idea of natural relationship began to dawn in a vague way. The actual purpose of all this plant study was the recording of the officinal plants, for special knowledge of plants was still confined to their uses in medicine.

While this movement was advancing in northern Europe, a mainly artificial system of classification was developing in Italy and found its culmination in the work of Caesalpino, who strongly influenced the progress of botany, even after his own time and into the middle of the eighteenth century. Great as was the advance he made, it would have been far greater had it been given him to break away from the scholastic philosophy which hampered him. We find a curious mixture of a modern spirit of inductive natural science and Aristotelian methods of thought. The latter triumphed in the main, and the result was a formal classification built on idealistic abstractions that is wholly fallacious from our standpoint of to-day.

Emerging from such conditions we find Linnaeus — the bicentenary of whose birth was celebrated last year — and though he too was much influenced by the earlier writers, to him belongs the credit of the emphasis on the fact that some natural system of the classification of plants must exist even though he could not determine it. Linnaeus is popularly termed the father of botany and of zoölogy as well, and in many senses there is reason for it. He was a born classifier and brought considerable order out of immense chaos, but still his classification was artificial, and only to a very limited degree recognized the natural relationships

of plant forms. Linnaeus, however, was wise enough to recognize its artificiality.

From Linnaeus the advance was more rapid, and, while most of the study in plants centered on the work of classification, there were unmistakable signs of other interests. The ideas of the classifier were still hampered by the dogma of the constancy of species, which continually clashed with the insistent and undeniable evidences of the genetic relationships of organic forms. Despite the movement in favor of the idea of the development of species from previously existing forms, despite the views advanced by Lamarck and others at about that time, despite, indeed, the more strictly botanical investigations in the morphological field which were brought forward during the first half of the nineteenth century: despite all these things, the botanist was unable to break away from the concept of groups of plants as abstract ideas. It was not until 1859 that the publication of Darwin's "Origin of Species" drove biologists to a different point of view. Then the rational idea of the evolution of organic forms explained in a similar rational fashion the observed genetic relationships of groups of plants. No longer did the classifier hesitatingly admit the possibility of the evolution of species and deny that of genera and higher groups, no longer did he maintain his artificial groups, which had no more relation to each other than successive throws of dice, but he admitted the whole great scheme implied by the evolution of organic forms from preëxisting types.

Naturally, it is difficult to point out at just what time the modern trend of botanical work found its origin, but one can say, in a general way, that it was about the middle of the nineteenth century, although of the two criteria of progress to which I shall refer, one dates about a decade before, the other about a decade after that time. The establishment by the botanist Schleiden in 1838, and by the zoölogist Schwann in 1839, of the real nature of the cell, and the acceptance of what may be termed the cell doctrine, at once made possible the development of the study of form and structure, both as to adult and as to embryonic organs. With improved optical apparatus and with improved technical methods, many able students added a vast number of

demonstrated facts to the general store of knowledge; in fact, for a time the additions to morphological information very much outran the development of the physiological side, though the latter had had a rational beginning at a prior date. The morphological development depended in the first instance upon the understanding that the cell with its living protoplast, and usually with a wall, constituted a not further divisible morphological unit of living organisms; that every cell must have arisen from a pre-existing one; and finally, that all but the lower organisms are composed of thousands of these cells differentiated into distinct tissues. One of the most important figures in this advance of botany from Schleiden's time was Naegeli, who brought to bear a powerful intellect on many of the fundamental concepts both of morphology and physiology. Of the many questions dealt with by him, that of the ultimate structure of organized substance was perhaps the most far-reaching; and to-day, despite its limitations, his Micellar Hypothesis is the most stimulating of any of the theories which have been developed regarding this subject.

The other milestone of progress was Darwin's "Origin of Species" already referred to. Entirely aside from the particular question involved in that work, its importance lies in the fact that it fought the battle and won the victory for the inductive method of reasoning as applied to biological science. Previous to the awakening of botany, due to these and related causes, a botanist usually covered the whole field of his science and had the right to consider himself a specialist in all branches of botany. The rapid accumulation of facts soon demanded, however, a segregation of different lines of work. Thus arose the divisions of botanical activity, which, for our purposes, may be classed under three heads. First, the taxonomic, or as more commonly called the systematic side, which has to do with the classification, mainly as established by gross morphology. Second, the morphological field, which concerns itself with the outward and inward form and structure and the development thereof, which may or may not have direct relation with taxonomic work. Third, there is the domain of physiology, which treats of function. As Professor Wilson has pointed out, there are really but two divisions of

biological work, the morphological and the physiological, so that the separation of taxonomy which really belongs in the first division is rather artificial. The separation however is necessary for many reasons, among which are the fact that the temper of mind and the methods of the workers in the two divisions are quite different.

It is perhaps the tendency of the time, at least in many quarters, to underestimate the value of taxonomic research and this is to be regretted since in classification we have the foundations of other branches of work. Entirely aside from the philosophical value of a well ordered classification, it is an absolute necessity for a starting point of morphology and physiology to have the different species of plants recorded in recognizable form, and, in consequence, to have a classification. It would undoubtedly be a great advantage could organisms be classified as are chemical compounds or could they be located as the astronomers locate the stars and in the same definite and precise manner. Such is hardly possible when we reflect that the question of the identity of an organism must, even under favorable conditions, be somewhat a matter of opinion as well as of demonstrated fact. Despite such limitations of taxonomy, in most of the really important questions opinion is fairly universal, so that our classification is not developed simply at the whim of any one investigator. Taxonomy, however, as soon as it is considered an end in itself sinks at once to the level of mere cataloguing or, worse still, loses itself in the mazes of nomenclatorial controversy. It must be considered in its relation to the problems of plant distribution, of the evolution of new forms, of its philosophical intent, if it is to retain its vitality.

I have spoken of artificial classifications in connection with the work of earlier botanists. How then does the natural classification as understood to-day differ? Primarily, it differs in the admission of genetic relationship of forms, a thing not conceived of by older writers. A natural classification implies higher and lower forms, connected by intermediate ones in all stages of differentiation. However, it does not imply that all these forms exist to-day, nor does it imply that they developed in a single

continuous series from the lowest to the highest. We have no particular right to suppose that all plants can be traced back to a single ancestor; indeed, the evidence is against it. There is no reason why several phyla, or lines of ascent, may not have originated, perhaps simultaneously, from the most primitive form of living protoplasm. The story of the lower aquatic forms certainly indicates this possibility. Of these lower phyla some stopped short, some went on, which ones is a matter to be definitely settled. A good instance, though a somewhat special one, to illustrate the fallacy of the assumption of a single line of relationship, is found among the fungi, the chlorophylless lower forms. Many ingenious authors have attempted to unite them in a single continuous series, when every evidence we now have points to their having originated at several places from the green plants. Who, indeed, would care to deny that new phyla might be originating to-day? Any concept of evolution demands such a possibility; organisms are more plastic than the average person conceives, even in this age.

The object of a natural classification is to consider all the many plant forms, to determine by such marks of genetic relationship as we can discover their place in the series, where they have departed from the main stem and in how far they may have had a line of development of their own. Despite what I have said about the lower phyla, it is not improbable that the higher plants can be traced back to some single source, not that it is to be believed for a moment that this ancestor exists to-day. Living ferns or mosses are no more to be considered the direct ancestors of the flowering plants than are monkeys to be considered the direct ancestors of man.

The establishment of our classification to-day might be compared to the putting together of a puzzle map some parts of which are lost; we can determine how many of the parts fit together, and, by analogy, can tell something of the missing ones. The whole method depends on the admission of genetic relationship, a concept that is built up partly by the study of adult structure, partly by the story of the developmental stages, partly, though in botany less than in zoölogy, by the evidence

of paleontology, but more vividly than in any other way by the actual behavior of certain plants in the matter of giving rise to new forms. This last consideration is of such great importance that we shall come back to it later.

One type of morphological investigation has to do with the study of life histories of plants — the whole life story from egg to egg again — and here we find the morphologist in close relation with the systematist, for upon the results of such researches must largely depend the understanding of the relationships of the great groups. The morphologist who devotes his time to the study of life histories is engaged in the work of tracing the race history of plants from the comparison of the individual development of more or less nearly related forms. Thus the homologies which have been traced among the flowering plants and their nearest allies among the ferns and other forms indicate to us the probable race history of these groups. It is true that the beginning of this work dates back some decades, but it is still, to a large extent, an open field, and numerous investigators are actively prosecuting research along these lines. For example, the alternation of a sexual and non-sexual generation of plants which has long been known as characteristic of the life histories of higher forms has recently been established among the lower groups, and thus a much clearer view of the whole series of the plant kingdom is being obtained.

Somewhat separated, and to a large extent needlessly so, is the work of the plant anatomist and histologist. Formerly pursued from the standpoint of the mere topographical relation of the parts, the conception of the plant as an organism with interrelated and interdependent tissues began to fall into abeyance, until a new point of view has within recent times revivified a somewhat barren field. This point of view is the physiological one, the correlation of structure and function. Here the student of gross morphology and the anatomist unite in a physiological interpretation of the form and structure of plant organs, from which has grown the study of experimental morphology. Advance in this direction has been considerable, and we have now a much clearer idea of the nature and development of plant

organs; or at least, we have a much better attitude in the interpretation of the facts that have been established regarding these matters. The danger which lies in this attitude is the well known one of teleological reasoning, and consequently it behooves us to have some caution in accepting, without thorough evidence, the interpretations which may be made of the relation of form and function and of special adaptations for special purposes. As some one has written, "so many things may be true and so few things really are in the matter of use of special organs," that we must demand above all things experimental evidence before we can accept as conclusively proved any statement as to function. It is permissible to say without such proof that such and such an explanation is plausible, but beyond that is uncertain ground and mere assertion shows a temerity at once magnificent and pitiable. On the other hand, it is questionable if the extreme attitude of iconoclasm as to long established interpretations is necessarily a wholly reasonable one. Destructive criticism is not difficult, and unless some new and better interpretation is suggested the advance in a scientific sense is not considerable.

A further development from this physiological attitude is a branch of biological work known as ecology, a study of the relation and adaptation of single plants or whole communities of plants to their environment and to each other. It is the application in a broad and more philosophical way of the methods of the physiological anatomist coupled with those of the taxonomist; but, in addition, the work of the botanist touches the field of the physiographer and geologist. Ecology is the endeavor to uncover the plan of nature as it governs the relations of the different plant forms in a given area, to understand the why and the wherefore of the association of very different forms in one locality. The keynote of the philosophical development of this topic rests on the conception of the constant struggle of individuals or groups of individuals to maintain themselves against other forms, which leads to a balanced relation of the different species in a given flora. Understanding this, we can see why, if this balance is disturbed, the whole fabric of a plant community may be destroyed and a flora swept away. We are also able to

understand how relatively slight climatic changes may alter completely the character of a vegetation in a given region, and thus to comprehend more readily the changes which must have taken place in past ages. It also shows us the effect of present changes, particularly in regard to the destruction by man of the essential elements of natural plant communities, notably one of the most important of these, the forests. Its use lies in these directions and the danger of its misuse lies in the direction of drawing too positive conclusions from data which are insufficient, and of accepting the results obtained as necessarily final, a common error it is true in any line of thought, but one to which the ecologist has especial temptation.

(*To be continued.*)

COLLECTING AND STUDYING BOLETI

By William A. Murrill

The *Boleti* are fleshy, tube-bearing fungi, the tubes separating quite easily from the flesh of the pileus and from each other. They usually occur on the ground in woods, not more than five of our species being found on decaying wood, and one being parasitic on a puff-ball.

The group always attracts attention on account of the brilliant colors and ephemeral character of its species, and is of special interest because of the large number of edible fungi found in it. One section, with red tube-mouths is considered distinctly dangerous, and some species are too bitter to eat; but with caution one might perhaps use for food over ninety per cent. of the *Boleti* he finds.

Boleti may be collected at any time from June to October, especially if there are frequent rains. In this latitude, July and August usually furnish the largest number of species. To make good specimens of *Boleti* for scientific purposes is probably the most difficult task that presents itself to the field mycologist, and one that he often shirks; which accounts for the scarcity of good specimens of these plants in most herbaria. With some care